

Ultra Long-Lived Autonomous Air Quality Sensing

Completed Technology Project (2017 - 2019)



Project Introduction

Year-1 progress on this CIF has demonstrated a 5-10 year lifetime using an RFID-based platform is achievable; this motivates a follow-on to the well-received PCO2M, which has demonstrated a capability for studying CO2 in microgravity but which cannot sustain autonomous operation over many months given its 4-day battery lifetime. We will spend year-2 finalizing the system for flight certification and subsequent demonstration on ISS (leading to an eventual Gateway deployment). We will next target an x-Project demonstration leveraging the RFID-enhanced Autonomous Logistics Management (REALM) RFID interrogator system already on ISS, requiring little investment for flight other than building the sensors themselves. This compatibility will also extend to the REALM-2 interrogator on the Astrobee free-flyer. Other gas nano-sensors (ammonia, CO, hydrazine, etc.) and low-power sensing modalities of high interest in Exploration Medicine may be included. Finally, the platform will provide a terrestrial path for assessing applicability of the CO2 nano-sensor to EVA/NBL helmet CO2 monitoring.

Anticipated Benefits

Long-lived environmental sensors directly enable untended vehicle autonomy as well as crew health monitoring and response to airborne contaminants. Bluetooth Personal CO2 Monitors (PCO2Ms) flying on ISS provide an initial capability, but need for frequent recharge (~4 days) allows limited scaling and no long-duration autonomy. We finalize the design of an ultra-low power wireless sensing platform (JSC) and integrate it with an ultra-low power CO2 sensor (ARC) to give a flight-certifiable, wearable or peel/stick platform that can operate for years at a time without battery recharge/replacement. The sensor will be forward-compatible with existing ISS RFID inventory management infrastructure for follow-on flight demos, and costs will be augmented by AES funding to integrate SBIR-produced location tracking sensors. This will provide a capability un-matched by any SoA wireless sensor package and can easily extend to other sensing modalities (ammonia, radiation, etc.), addressing the JSC technology priority area of Automation and ECLSS. Dr. Steve Horan (STMD Avionics PT) agrees that this infusion path is reasonable and this work is in alignment with the PT for Avionics quantifiable capabilities. Long-lived environmental sensors directly enable untended vehicle autonomy as well as crew health monitoring and response to airborne contaminants. Bluetooth Personal CO2 Monitors (PCO2Ms) flying on ISS provide an initial capability, but need for frequent recharge (~4 days) allows limited scaling and no long-duration autonomy. We advance the design of an ultra-low power wireless sensing platform (JSC) and integrate it with a low power CO2 sensor (ARC custom or COTS) to give a flight-certifiable, wearable or peel/stick platform that can operate for years at a time without battery recharge/replacement. The sensor will be forward-compatible with existing ISS RFID inventory management infrastructure for follow-on flight demos, and costs will be augmented by Advanced Exploration Systems (AES) funding to



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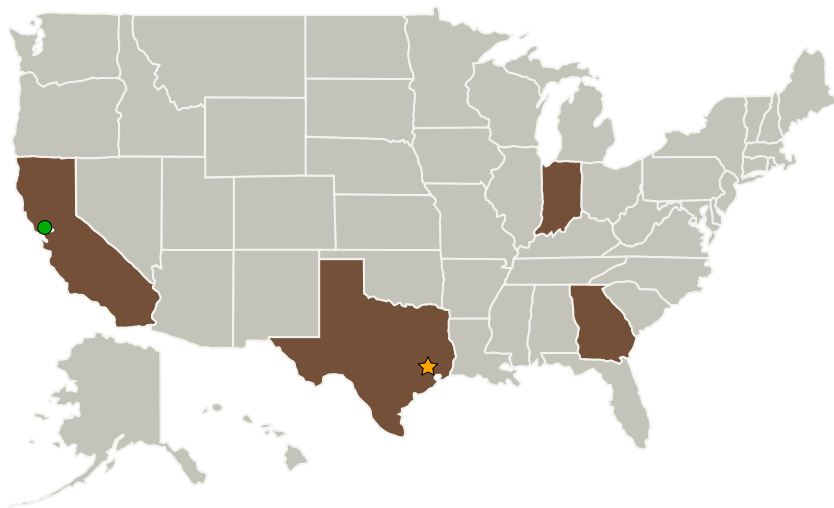
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integrate Small Business Innovation Research (SBIR)-produced location tracking sensors. This will provide a capability un-matched by any state-of-the-art (SoA) wireless sensor package and can easily extend to other sensing modalities (ammonia, radiation, etc.), addressing the JSC technology priority area of Automation and Environmental Control and Life Support System (ECLSS).

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
● Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California
Brigham And Women's Hospital, Inc.	Supporting Organization	Industry	Boston, Massachusetts
Harvard University	Supporting Organization	Academia	Petersham, Massachusetts

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Center Innovation Fund: JSC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

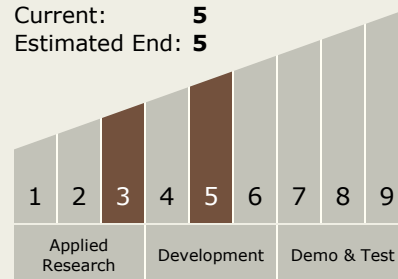
Carlos H Westhelle

Principal Investigator:

Raymond O Wagner

Technology Maturity (TRL)

Start: 3
Current: 5
Estimated End: 5



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Co-Funding Partners	Type	Location
Ames Research Center(ARC)	NASA Center	Moffett Field, California

Primary U.S. Work Locations	
California	Georgia
Indiana	Texas

Project Transitions

 **October 2017:** Project Start

 **September 2019:** Closed out

Closeout Summary: Environmental sensing will be key to autonomous vehicle operation and crew health monitoring in tended/untended long-duration habitats for Human Space Exploration in deep space. Small wireless sensors, based on Radio Frequency Identification (RFID) technology, can provide unprecedented capacity to monitor crew/habitat health. We are developing a next-generation, wireless air quality sensor capable of operating for years on a small coin-cell battery without crewmember intervention. Integrating a state-of-the-art commercial CO₂ sensor, this platform can acquire and wirelessly transport samples with a projected battery lifetime of to 27.5 years on a CR2450 coin cell (10 mins./sample). Having proven the feasibility of store-and-forward data transport using RFID links in year 1, we have focused this year on integrating the algorithm into the RFID-enhanced Autonomous Logistics Management (REALM) to study both its impact on REALM inventory management and REALM's impact on RFID data transfer. These experiments have guided a re-implementation that will position REALM for RFID sensing support on Station/Gateway. We have also designed and implemented an interface to the most advanced COTS CO₂ sensor available as an alternative to the ARC CO₂ nano-materials sensor, whose continues at ARC. With improvements in reducing quiescent current consumption, at duty cycles comparable to PCO₂M, this exceeds the high end of the promised range with a lifetime in excess of 13 years CR2032 coin cell, and with a slightly larger CR2450, it will achieve close in excess of 27.5 years. As a next step, we plan to infuse position sensing into the platform and transition this to a flight implementation under AES Logistics Management to demonstrate on ISS with REALM-1.

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VC

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
 - ↳ TX06.3 Human Health and Performance
 - ↳ TX06.3.4 Contact-less / Wearable Human Health and Performance Monitoring

Target Destinations

Earth, The Moon, Mars